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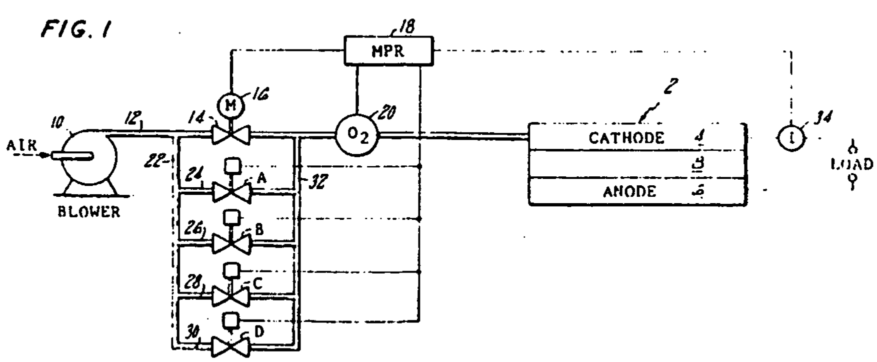
(54) Augmented air supply for fuel cells power plant during transient load increases.

(57) The performance of fuel cell power plants using air as the oxygen source is reduced during periods of load increase because the response of the fuel cells to the load change is relatively instantaneous. While cell response is instantaneous, changes in air supply are not. In order to temporarily increase the air supply to the cells during such a load change, auxiliary solenoid operated valves having high response characteristics are opened to allow greater air flow to the cells. When the oxygen flow rate is determined to be sufficient for the measured load, the auxiliary valves are closed.

FIG. 1



EP 0 293 007 A2

Augmented Air Supply for Fuel Cell Power Plant During Transient Load Increases

Technical Field

This invention relates to fuel cell power plants, and specifically to fuel cell power plants which provide increased air flow to the cells during increased power transitions.

Background Art

Fuel cell power systems which utilize air as an oxygen source such as disclosed in U.S. Patent No. 3,576,677 to Keating, Jr., et al. will typically supply the air with a constant air supply blower having a modulated outlet control valve to maintain optimum oxygen utilization in the cells, thereby permitting water recovery and good cell performance. The modulated valve will generally be a relatively slow motorized valve. For the vast majority of operating conditions, such an oxygen supply system is perfectly adequate. An exception can occur, however, when increased power load demands are imposed on the cells. One of the positive aspects of fuel cell power plant systems is that they are substantially instantaneous in responding to demands in increased current output or load. When an increase in load is met by a fuel cell power plant, a concurrent and equally quick increase in reactant supply should also occur to ensure proper operation of the fuel cell power plant. This is especially true for large scale increases in power output. This relatively instantaneous increase in oxygen supply will not occur with the prior art motorized modulated air supply valve because this type of valve is incapable of such quick changes in its capacity, especially in large size butterfly valves. It can take the conventional motorized modulating valve a number of seconds to adjust its feed rate to a new higher rate required because of an increase in load imposed on the power plant. During this interval, oxygen starvation can occur causing unstable operating conditions. Reduced cell voltage, increased current, fuel starvation and anode corrosion can result. The power plant will fail to produce the power demanded and may shut down due to out of limits conditions.

Disclosure of Invention

This invention provides for improved cell performance during periods of power output increases by incorporating a plurality of auxiliary air supply valves in parallel lines from the blower to the oxygen inlet side of the cell stack, which parallel lines bypass the modulating valve. The auxiliary valves are fast acting solenoid valves, typically operating in about 100 milliseconds after being energized. These valves are normally closed during operation of the power plant, and open for transient periods of time, only on command. Operation of the power plant is preferably controlled by a microprocessor. A current sensor connected to the microprocessor control is operable to monitor the power output of the power section. The microprocessor controls both the modulating valve and the solenoid valves. When an increase in power output is detected and relayed to the microprocessor, the latter opens a set of the solenoid auxiliary valves and also signals the modulating valve to adjust to allow more air into the power section. The microprocessor is programmed to close the auxiliary valves once the modulating valve has opened to the degree required by the magnitude of the sensed power output increase. There will preferably be more than one auxiliary valve set to provide for markedly increased air flow in the event that the load increase is excessive.

It is therefore an object of this invention to provide an improved fuel cell power plant with safeguards against oxygen starvation occurring when increases in power output are imposed upon the cells.

It is another object of this invention to provide a power plant of the character described which operates with a constant output pressurized air blower to provide air to the fuel cells through a primary variable flow rate valve.

It is an additional object of this invention to provide a power plant of the character described wherein auxiliary air is supplied to the cells subsequent to an increase in power output of the plant.

It is a further object of this invention to provide a power plant of the character described wherein the supply of auxiliary air is terminated after adjustment of the primary variable flow rate valve is completed.

It is yet another object of this invention to provide a power plant of the character described wherein the primary and auxiliary air valves are controlled by a microprocessor which reacts to input from a current sensor monitoring the load on the fuel cells.

These and other objects and advantages of the invention will become more readily apparent from the following detailed description of a preferred embodiment of the invention when taken in conjunction with the accompanying drawings.

Brief Description of the Drawings

Fig. 1 is a schematic diagram of a portion of a preferred embodiment of a fuel cell power plant formed in accordance with this invention.

Fig. 2 is a graphic representation of the manner in which actual load changes occur in the power plant and the manner in which oxygen flow chances in response to modulation of the motorized air flow valve; and

Fig. 3 is a software flow chart outlining the manner in which the microprocessor control for the power plant controls the solenoid valves and the primary air flow control valve.

Best Mode for Carrying Out the Invention

Referring now to Fig. 1, there is shown in schematic form, the air supply portion and power section of a fuel cell power plant which operates in accordance with this invention. The power section, denoted generally by the numeral 2, includes a cathode side 4, an anode side 6 and and an intermediate electrolyte matrix portion 8. While the power section 2 is shown in the schematic diagram as a single fuel cell, it will be readily appreciated that the power section will actually typically comprise one or more stacks of fuel cells. Oxygen is supplied to the cathode side 4 of the power section 2 by a constant speed blower 10 which blows ambient air into the cathode side via air conduit 12. A primary air flow control valve 14 is mounted in the cathode inlet air conduit 12, the valve 14 being a modulated valve which is operated by fixed rate motor 16, which, in turn, is controlled by the power plant microprocessor control 18. The control 18 is thus able to adjust the rate at which air flows through the valve 14 by selectively operating the motor 16. A flow meter 20 is mounted in the conduit 12 between the primary control valve 14 and the cathode side 4 of the power section 2 to monitor the flow rate of oxygen entering the cathode. The flow meter 20 is preferably a solid state mass flow meter, and is also operably connected to the power plant microprocessor control 18.

Upstream of the primary air flow control valve 14, between the latter and the blower 10, there is disposed a first branch air conduit 22 which leads to flow bypass conduits 24, 26, 28 and 30. Each of the bypass conduits 24, 26, 28 and 30 has mounted therein a solenoid valve A, B, C and D respectively. The solenoid valves A, B, C and D are quick opening valves which are either fully closed or fully open, and are normally biased closed during operation of the power plant. The solenoid valves A, B, C and D are operably connected to the power plant microprocessor control 18, and are selectively operated thereby, as will be set forth in greater detail hereinafter. The bypass conduits 24, 26, 28 and 30 are connected to a second branch conduit 32 which reenters the oxygen inlet conduit 12 downstream of the primary air flow control valve 14. A current or load monitor 34 is connected to the power plant production circuit to monitor the current being produced by the power section 2. The current monitor 34 is also operably connected to the power plant microprocessor control 18.

Referring now to Fig. 2, a graphic representation of output current demand, or load, is shown for the power section during a transient increase, and also during opening of the motorized primary control valve 14. In Fig. 2, the Y axis denotes load or current I in amps, and the X axis denotes time T. The solid line indicates a change in load during a power demand transient increase, and the phantom line denotes theoretical current production change or power delivered as a result of increased oxygen flow to the cathode due to opening of the motorized valve. Since the changes in load occur substantially instantaneously while the changes in oxygen flow increase steadily at a fixed rate so long as the motorized control valve is being opened, there will be a difference in load current demand and theoretical current produced by available oxygen from the motorized control valve, this difference being denoted by $I\Delta$ in Fig. 2. It will be seen that $I\Delta$ will steadily decrease as the motorized valve opens until the oxygen flow rate through the motorized valve is sufficient to supply the load current demand. It is during time periods when there exists an $I\Delta$ that risk of oxygen starvation and performance deficit is present. The greater the $I\Delta$ when the load transient increase occurs, the longer time it will take the oxygen flow rate through the motorized valve to catch up, and the greater the danger of cell damage.

The microprocessor control 18 is constantly fed information from the flow meter 20 so that the microprocessor control 18 always knows the existing setting of the motorized control valve 14. Likewise, the control 18 is preprogrammed to know the fixed rate at which the control valve 14 opens and closes. The current output monitor 34 constantly feeds information to the control 18 as to the existing load imposed on the power section 2. Whenever the imposed load increases, the control 18 can calculate the time needed for opening the control valve 14 until the control valve 14 will reach a setting that will satisfy the increased load with oxygen flowing through the valve 14. The control 18 is preprogrammed to selectively open some or all of the auxiliary solenoid valves A, B, C and D upon detecting an $I\Delta$ value which is above one or more preselected values, and is also preprogrammed to selectively close the solenoid valves A, B,

C and D when the IΔ drops below one or more lower preselected values. The preselected opening IΔ values are such that the power section 2 will not risk damage from relying solely on the motorized valve 14 when presented with initial IΔ values that are less than the preselected opening IΔ values. The preselected closing IΔ values are low enough to ensure that the solenoid valves will not be constantly opening and closing, and thus incurring wear, simply because IΔ fluctuates near the preselected IΔ opening values during operation of the system. If the control 18 is fed an IΔ value from the output monitor 34 which does not exceed the lower preprogrammed opening IΔ value, then the control 18 will calculate the time needed to open the motorized valve 14 to meet the new IΔ, and will then open the motorized valve for that calculated time period.

Referring now to Fig. 3, there is shown a software flow chart which describes operation of the microprocessor control 18, and the valves 14, as well as the solenoid valves A, B, C and D. In the system shown in Fig. 3, the solenoid valves are operated as pairs, so that valves A and B will open and close together, and valves C and D will also open and close together. This mode of operation is merely one of many modes in which the invention can be used, and was selected primarily because of the sizes of commercially available solenoid valves. Also, in the system described in Fig. 3, the valve pair A and B open and close first, while the valve pair C and D open and close second. This means merely that if the IΔ measured is such that only two solenoid valves are needed to augment the motorized valve, then A and B will be opened and C and D will remain closed. In the procedure outlined in Fig. 3, it will be noted that the microprocessor checks the condition of the initial solenoid valves A and B at half second intervals and adjusts the motorized valve accordingly. If, in these half second sweeps, the solenoid valves A and B are found to be closed, the control compares the oxygen flow rate schedule W with the actual flow rate and adjusts the motorized valve accordingly. At one tenth of a second intervals, the control checks both valve sets A, B and C, D and checks the current ramp function F, which is related to IΔ, and decides whether A, B and C, D should be opened or closed. It is noted that the valves A and B are checked first and properly adjusted, whereafter the valves C and D are checked and properly adjusted. It will also be noted that the half second sweeps are followed by the tenth of a second check of the solenoid valves.

It will be readily understood that the system of this invention is simple to install and automatically operable by appropriately programming a microprocessor power plant control system. Oxygen starvation during transient load increases is prevented, but the cells are not fed excessive amounts of oxygen for long periods of time diluting the power plant exhaust so that the recovery of product water is not adversely affected. The hardware used to construct the system of this invention is commercially available so that the system is relatively economical to construct. In addition, existing systems can be readily retrofitted to operate in accordance with this invention.

Since many changes and variations of this disclosed embodiment of the invention may be made without departing from the inventive concept, it is not intended to limit the invention otherwise than as required by the appended claims.

Claims

1. In a fuel cell power plant, a system for supplying air to an oxidation side of the cells in the plant, said system comprising:

a) conduit means for feeding air to said oxidation side of said plant;

b) a constant speed blower connected to said conduit means for blowing an air stream into said conduit means at a constant velocity;

c) a motorized control valve in said conduit means between said blower and said oxidation side, said control valve being adjustable to vary the amount of air flowing to said oxidation side;

d) branch conduit means opening into said conduit means for providing an air flow path from said blower to said oxidation side which bypasses said control valve;

e) fast acting valve means in said branch conduit means, said fast acting valve means being relatively instantly transformable from a closed condition to an open condition and return, and said fast acting valve means being normally in said closed conditon:

f) flow meter means in said conduit means for measuring amounts of oxygen flowing from said control valve and said fast acting valve means to said oxidation side;

g) current monitoring means connected to a load line from the power plant for monitoring load changes imposed upon the cells in the power plant; and

h) microprocessor means for controlling operation of said system, said microprocessor means being operably connected to said current monitoring means, to said flow meter means, to said fast acting valve means, and to said control valve, said microprocessor means being operable to:

i) receive load and oxygen flow data from said monitoring and sensor means respectively;

ii) continually determine if said control valve is

capable of providing sufficient oxygen to satisfy existing load demands:

iii) open said control valve incrementally when said control valve can independently provide increased oxygen in a timely manner responsive to increased load demand; and

iv) open said fast acting valve means and simultaneously open said control valve in continued fashion, when said control valve cannot independently provide increased oxygen in a timely manner responsive to increased load demand, whereby the lower plant will not suffer from oxygen starvation during transient increases in load demand.

2. The fuel cell power plant system of claim 1 wherein said microprocessor means is further operable to close said fast acting valve means when existing oxygen flow rate from said fast acting valve means and said control valve reaches a previously inputted value which is a precalculated amount capable of supporting the concurrently existing load demand.

3. The fuel cell power plant system of claim 1 or 2 wherein said fast acting valve means comprises a plurality of solenoid valves, and wherein said microprocessor means is operable to open less than all of said solenoid valves when oxygen supply shortfall from said control valve is a smaller first precalculated amount less than that required to support ongoing load demand, and is further operable to open all of said solenoid valves when oxygen supply shortfall from said control valve is a second larger amount less than that required to support ongoing load demand.

4. A method for supplying oxygen to a fuel cell system during extended operating periods, said method comprising the steps of:

a) continuously monitoring load demand imposed on said fuel cell system;

b) continuously monitoring oxygen flow rate into said fuel cell system;

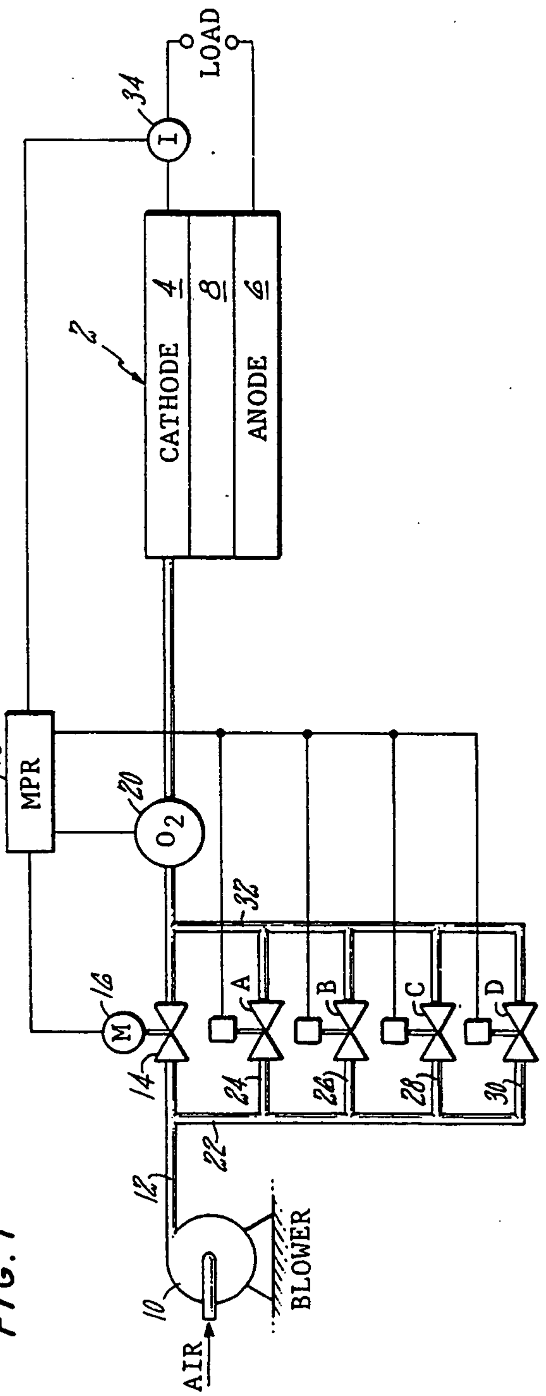
c) periodically comparing measured loads and measured oxygen flow rates with a precalculated steady state flow schedule and comparing measured oxygen flow rate deviations from said steady state flow schedule;

d) gradually increasing the oxygen flow rates to the fuel cell system when said measured oxygen flow rate deviations are less than a first predetermined value; and

e) simultaneously substantially instantaneously providing augmented oxygen flow to increase the oxygen flow rates to the fuel cell system when said oxygen flow rate deviations exceed said first predetermined value.

5. The method of claim 4 further comprising the step of substantially instantaneously terminating the augmented oxygen flow when said oxygen flow rate deviations are below a second predetermined value which second predetermined value is less than said first predetermined value.

6 The method of claim 5 further comprising the step of continuing to gradually increase the oxygen flow rates after terminating the augmented oxygen flow, until such time as the measured oxygen flow rates conform to the precalculated steady state flow schedule, and thereafter providing a steady flow of oxygen will respond to negative deviations, too, by closing the motorized valve.



AIR
BLOWER
10
12
22
14
16
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28
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6
34
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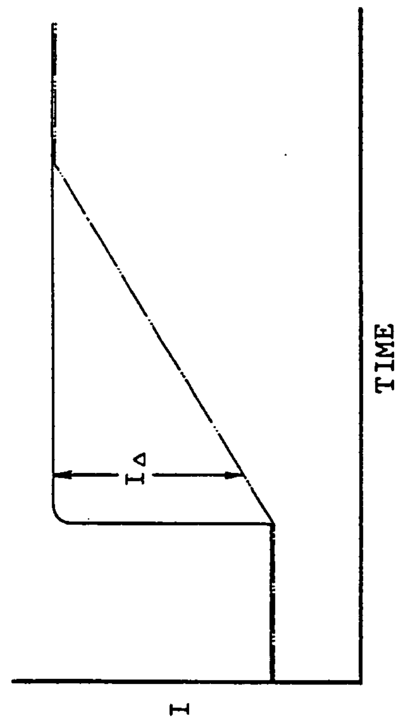
FIG. 1



I
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FIG. 2

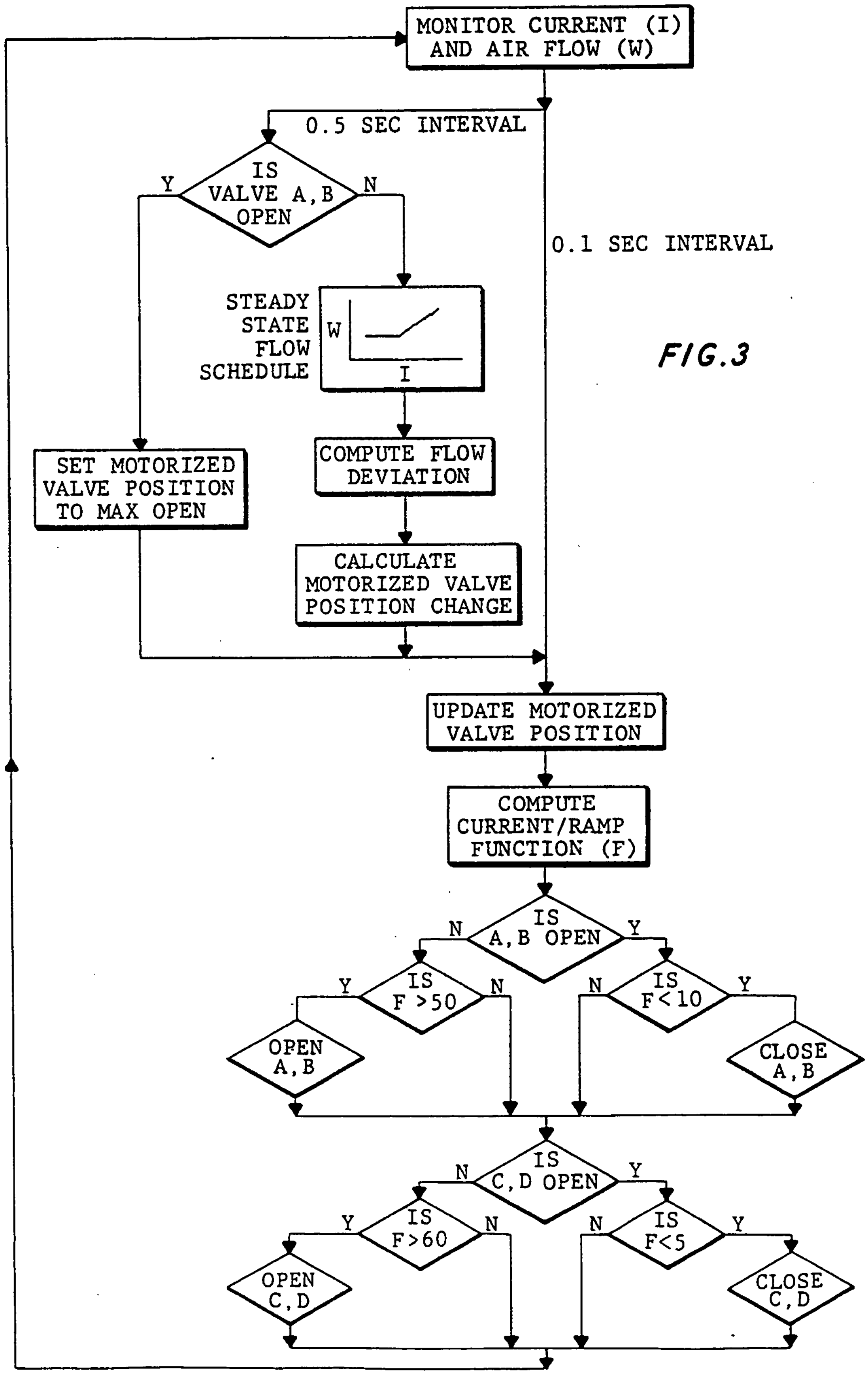
MONITOR CURRENT (I) AND AIR FLOW (W)
0.5 SEC INTERVAL
0.1 SEC INTERVAL
IS VALVE A,B OPEN
Y
N
STEADY STATE FLOW SCHEDULE
W
I
SET MOTORIZED VALVE POSITION TO MAX OPEN
COMPUTE FLOW DEVIATION
CALCULATE MOTORIZED VALVE POSITION CHANGE
UPDATE MOTORIZED VALVE POSITION
COMPUTE CURRENT/RAMP FUNCTION (F)
IS A,B OPEN
IS F >50
IS F<10
OPEN A,B
CLOSE A,B
IS C,D OPEN
IS F>60
IS F<5
OPEN C,D
CLOSE C,D

FIG.3

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(54) **Augmented air supply for fuel cells power plant during transient load increases.**

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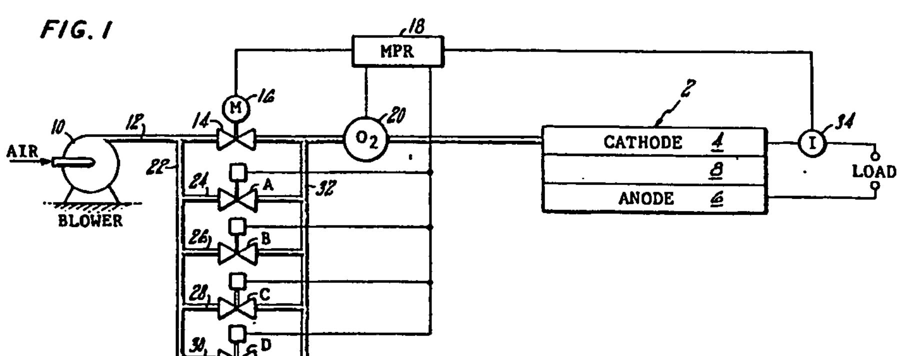
FIG. I



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EUROPEAN SEARCH REPORT

Application Number

EP 88 10 8538

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	PATENT ABSTRACTS OF JAPAN, vol. 10, no. 240 (E-429)[2296], 19th August 1986; & JP-A-61 71 560 (FUJI ELECTRIC CO., LTD) 12-04-1986 * Whole Abstract * ---	4	H 01 M 8/04
A	PATENT ABSTRACTS OF JAPAN, vol. 9, no. 240 (E-345)[1963], 26th September 1985; & JP-A-60 91 569 (TOSHIBA K.K.) 22-05-1985 * Abstract * ---	4	
A	PATENT ABSTRACTS OF JAPAN, vol. 9, no. 240 (E-345)[1963], 26th September 1985; & JP-A-60 91 568 (TOSHIBA K.K.) 22-05-1985 * Abstract * ---	4	
A	PATENT ABSTRACTS OF JAPAN, vol. 10, no. 65 (E-388)[2122], 14th March 1986; & JP-A-60 216 467 (HITACHI SEISAKUSHO K.K.) 29-10-1985 * Abstract * ---	4	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	PATENT ABSTRACTS OF JAPAN, vol. 6, no. 243 (E-145)[1121], 2nd December 1982; & JP-A-57 143 269 (SHINKOUBE DENKI K.K.) 04-09-1982 ---		H 01 M
A	GB-A-1 295 862 (ENERGY CONVERSION) ---		
A	GB-A-1 150 282 (ENERGY CONVERSION) ---		
P,A	US-A-4 693 945 (H. OHYAUCHI et al.) --- -/-		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16-05-1989	D'HONDT J.W.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

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EUROPEAN SEARCH REPORT

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A	PATENT ABSTRACTS OF JAPAN, vol. 10, no. 87 (E-393)[2144], 5th April 1986; & JP-A-60 230 364 (TOSHIBA K.K.) 15-11-1985 * Abstract * ---	4	
P,A	PATENT ABSTRACTS OF JAPAN, vol. 12, no. 135 (E-604)[2982], 23rd April 1988; & JP-A-62 529 353 (TOSHIBA CORP.) 11-11-1987 * Abstract * -----	4	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)

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(56) References cited:
GB-A- 1 150 282
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US-A- 4 693 945

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Description

Technical Field

This invention relates to fuel cell power plants, and specifically to fuel cell power plants which provide increased air flow to the cells during increased power transitions.

Background Art

Fuel cell power systems which utilize air as an oxygen source such as disclosed in U.S. Patent No. 3,576,677 to Keating, Jr., et al. will typically supply the air with a constant air supply blower having a modulated outlet control valve to maintain optimum oxygen utilization in the cells, thereby permitting water recovery and good cell performance. The modulated valve will generally be a relatively slow motorized valve. For the vast majority of operating conditions, such an oxygen supply system is perfectly adequate. An exception can occur, however, when increased power load demands are imposed on the cells. One of the positive aspects of fuel cell power plant systems is that they are substantially instantaneous in responding to demands in increased current output or load. When an increase in load is met by a fuel cell power plant, a concurrent and equally quick increase in reactant supply should also occur to ensure proper operation of the fuel cell power plant. This is especially true for large scale increases in power output. This relatively instantaneous increase in oxygen supply will not occur with the prior art motorized modulated air supply valve because this type of valve is incapable of such quick changes in its capacity, especially in large size butterfly valves. It can take the conventional motorized modulating valve a number of seconds to adjust its feed rate to a new higher rate required because of an increase in load imposed on the power plant. During this interval, oxygen starvation can occur causing unstable operating conditions. Reduced cell voltage, increased current, fuel starvation and anode corrosion can result. The power plant will fail to produce the power demanded and may shut down due to out of limits conditions.

In Patent Abstracts of Japan, Vol. 9, No. 240 (E345) [1963], 26th September 1985, it is disclosed to adjust the amount of oxident gas to the actual demands by load dependent feedback control.

In Patent Abstracts of Japan, Vo. 10, No. 240 (E429) [2296], 19th August 1986, it is disclosed to avoid delayed feeding of reaction gas to fuel cells by storing reaction gas in an accumulator and adding a required amount thereof to the reaction gas supplied to the fuel cells, the amount being controlled by making use of rapid changes in cell load.

In JP-A-61 263 065 it is diclosed to avoid temporary shortage of fuel and oxygen when the power load connected to the fuel cell system rises abruptly by providing fuel and oxygen gas sources adapted to supply a required amount of fuel or oxygen gas into the respective feed passage upon receiving a load rise signal.

Disclosure of Invention

This invention provides for improved cell performance during periods of power output increases by incorporating a plurality of auxiliary air supply valves in parallel lines from the blower to the oxygen inlet side of the cell stack, which parallel lines bypass the modulating valve. The auxiliary valves are fast acting solenoid valves, typically operating in about 100 milliseconds after being energized. These valves are normally closed during operation of the power plant, and open for transient periods of time, only on command. Operation of the power plant is preferably controlled by a microprocessor. A current sensor connected to the microprocessor control is operable to monitor the power output of the power section. The microprocessor controls both the modulating valve and the solenoid valves. When an increase in power output is detected and relayed to the microprocessor, the latter opens a set of the solenoid auxiliary valves and also signals the modulating valve to adjust to allow more air into the power section. The microprocessor is programmed to close the auxiliary valves once the modulating valve has opened to the degree required by the magnitude of the sensed power output increase. There will preferably be more than one auxiliary valve set to provide for markedly increased air flow in the event that the load increase is excessive.

It is therefore an object of this invention to provide an improved fuel cell power plant with safeguards against oxygen starvation occurring when increases in power output are imposed upon the cells.

It is another object of this invention to provide a power plant of the character described which operates with a constant output pressurized air blower to provide air to the fuel cells through a primary variable flow rate valve.

It is an additional object of this invention to provide a power plant of the character described wherein auxiliary air is supplied to the cells subsequent to an increase in power output of the plant.

It is a further object of this invention to provide a power plant of the character described wherein the supply of auxiliary air is terminated after adjustment of the primary variable flow rate valve is completed.

It is yet another object of this invention to provide a power plant of the character described wherein the primary and auxiliary air valves are controlled by a microprocessor which reacts to input from a current sensor monitoring the load on the fuel cells.

These and other objects and advantages of the invention will become more readily apparent from the following detailed description of a preferred embodiment of the invention when taken in conjunction with the accompanying drawings.

Brief Description of the Drawings

Fig. 1 is a schematic diagram of a portion of a preferred embodiment of a fuel cell power plant formed in accordance with this invention.

Fig. 2 is a graphic representation of the manner in which actual load changes occur in the power plant and the manner in which oxygen flow chances in response to modulation of the motorized air flow valve; and

Fig. 3 is a software flow chart outlining the manner in which the microprocessor control for the power plant controls the solenoid valves and the primary air flow control valve.

Best Mode for Carrying Out the Invention

Referring now to Fig. 1, there is shown in schematic form, the air supply portion and power section of a fuel cell power plant which operates in accordance with this invention. The power section, denoted generally by the numeral 2, includes a cathode side 4, an anode side 6 and and an intermediate electrolyte matrix portion 8. While the power section 2 is shown in the schematic diagram as a single fuel cell, it will be readily appreciated that the power section will actually typically comprise one or more stacks of fuel cells. Oxygen is supplied to the cathode side 4 of the power section 2 by a constant speed blower 10 which blows ambient air into the cathode side via air conduit 12. A primary air flow control valve 14 is mounted in the cathode inlet air conduit 12, the valve 14 being a modulated valve which is operated by fixed rate motor 16, which, in turn, is controlled by the power plant microprocessor control 18. The control 18 is thus able to adjust the rate at which air flows through the valve 14 by selectively operating the motor 16. A flow meter 20 is mounted in the conduit 12 between the primary control valve 14 and the cathode side 4 of the power section 2 to monitor the flow rate of oxygen entering the cathode. The flow meter 20 is preferably a solid state mass flow meter, and is also operably connected to the power plant microprocessor control 18.

Upstream of the primary air flow control valve 14, between the latter and the blower 10, there is disposed a first branch air conduit 22 which leads to flow bypass conduits 24, 26, 28 and 30. Each of the bypass conduits 24, 26, 28 and 30 has mounted therein a solenoid valve A, B, C and D respectively. The solenoid valves A, B, C and D are quick opening valves which are either fully closed or fully open, and are normally biased closed during operation of the power plant. The solenoid valves A, B, C and D are operably connected to the power plant microprocessor control 18, and are selectively operated thereby, as will be set forth in greater detail hereinafter. The bypass conduits 24, 26, 28 and 30 are connected to a second branch conduit 32 which reenters the oxygen inlet conduit 12 downstream of the primary air flow control valve 14. A current or load monitor 34 is connected to the power plant production circuit to monitor the current being produced by the power section 2. The current monitor 34 is also operably connected to the power plant microprocessor control 18.

Referring now to Fig. 2, a graphic representation of output current demand, or load, is shown for the power section during a transient increase, and also during opening of the motorized primary control valve 14. In Fig. 2, the Y axis denotes load or current I in amps, and the X axis denotes time T. The solid line indicates a change in load during a power demand transient increase, and the phantom line denotes theoretical current production change or power delivered as a result of increased oxygen flow to the cathode due to opening of the motorized valve. Since the changes in load occur substantially instantaneously while the changes in oxygen flow increase steadily at a fixed rate so long as the motorized control valve is being opened, there will be a difference in load current demand and theoretical current produced by available oxygen from the motorized control valve, this difference being denoted by $I\Delta$ in Fig. 2. It will be seen that $I\Delta$ will steadily decrease as the motorized valve opens until the oxygen flow rate through the motorized valve is sufficient to supply the load current demand. It is during time periods when there exists an $I\Delta$ that risk of oxygen starvation and performance deficit is present. The greater the $I\Delta$ when the load transient increase occurs, the longer time it will take the oxygen flow rate through the motorized valve to catch up, and the greater the danger of cell damage.

The microprocessor control 18 is constantly fed information from the flow meter 20 so that the microprocessor control 18 always knows the existing setting of the motorized control valve 14. Likewise, the control 18 is preprogrammed to know the fixed rate at which the control valve 14 opens and closes. The current output monitor 34 constantly feeds information to the control 18 as to the exist-

ing load imposed on the power section 2. Whenever the imposed load increases, the control 18 can calculate the time needed for opening the control valve 14 until the control valve 14 will reach a setting that will satisfy the increased load with oxygen flowing through the valve 14. The control 18 is preprogrammed to selectively open some or all of the auxiliary solenoid valves A, B, C and D upon detecting an IΔ value which is above one or more preselected values, and is also preprogrammed to selectively close the solenoid valves A, B, C and D when the IΔ drops below one or more lower preselected values. The preselected opening IΔ values are such that the power section 2 will not risk damage from relying solely on the motorized valve 14 when presented with initial IΔ values that are less than the preselected opening IΔ values. The preselected closing IΔ values are low enough to ensure that the solenoid valves will not be constantly opening and closing, and thus incurring wear, simply because IΔ fluctuates near the preselected IΔ opening values during operation of the system. If the control 18 is fed an IΔ value from the output monitor 34 which does not exceed the lower preprogrammed opening IΔ value, then the control 18 will calculate the time needed to open the motorized valve 14 to meet the new IΔ, and will then open the motorized valve for that calculated time period.

Referring now to Fig. 3, there is shown a software flow chart which describes operation of the microprocessor control 18, and the valves 14, as well as the solenoid valves A, B, C and D. In the system shown in Fig. 3, the solenoid valves are operated as pairs, so that valves A and B will open and close together, and valves C and D will also open and close together. This mode of operation is merely one of many modes in which the invention can be used, and was selected primarily because of the sizes of commercially available solenoid valves. Also, in the system described in Fig. 3, the valve pair A and B open and close first, while the valve pair C and D open and close second. This means merely that if the IΔ measured is such that only two solenoid valves are needed to augment the motorized valve, then A and B will be opened and C and D will remain closed. In the procedure outlined in Fig. 3, it will be noted that the microprocessor checks the condition of the initial solenoid valves A and B at half second intervals and adjusts the motorized valve accordingly. If, in these half second sweeps, the solenoid valves A and B are found to be closed, the control compares the oxygen flow rate schedule W with the actual flow rate and adjusts the motorized valve accordingly. At one tenth of a second intervals, the control checks both valve sets A, B and C, D and checks the current/ramp function F, which is related to IΔ, and decides whether A, B and C, D should be opened or closed. It is noted that the valves A and B are checked first and properly adjusted, whereafter the valves C and D are checked and properly adjusted. It will also be noted that the half second sweeps are followed by the tenth of a second check of the solenoid valves.

It will be readily understood that the system of this invention is simple to install and automatically operable by appropriately programming a microprocessor power plant control system. Oxygen starvation during transient load increases is prevented, but the cells are not fed excessive amounts of oxygen for long periods of time diluting the power plant exhaust so that the recovery of product water is not adversely affected. The hardware used to construct the system of this invention is commercially available so that the system is relatively economical to construct. In addition, existing systems can be readily retrofitted to operate in accordance with this invention.

Claims

1. A fuel cell power plant with a system for supplying oxygen to an oxidation side (4) of the cells in the plant, said system comprising:
   (a) conduit means (12) for feeding oxygen to said oxidation side (4) of said plant;
   (b) a constant speed blower (10) connected to said conduit means (12) for providing the required feed of oxygen.
   (c) a motorized control valve (14) in said conduit means (12) between said blower (10) and said oxidation side (4), said control valve being adjustable to vary the amount of oxygen flowing to said oxidation side;
   (d) branch conduit means (22, 24, 26, 28, 30, 32) opening into said conduit means (12) for providing an oxygen flow path from said blower (10) to said oxidation side (4) which bypasses said control valve (14);
   (e) fast acting valve means (A, B, C, D) in said branch conduit means, said fast acting valve means being relatively instantly transformable from a closed condition to an open condition and return, and said fast acting valve means being normally in said closed condition;
   (f) flow meter means (20) in said conduit means (12) for measuring amounts of oxygen flowing from said control valve (14) and said fast acting valve means (A, B, C, D) to said oxidation side (4);
   (g) current monitoring means (34) connected to a load line from the power plant for monitoring load changes imposed upon the cells (2) in the power plant; and

(h) microprocessor means (18) for controlling operation of said system, said microprocessor means being operably connected to said current monitoring means (34), to said flow meter means (20), to said fast acting valve means (A, B, C, D), and to said control valve (14), said microprocessor means being operable to:

(i) receive load and oxygen flow data from said monitoring (34) and sensor (20) means, respectively;

(ii) continually determine if said control valve (14) is capable of providing sufficient oxygen to satisfy existing load demands;

(iii) open said control valve (14) incrementally when said control valve can independently provide increased oxygen in a timely manner responsive to increased load demand; and

(iv) open said fast acting valve means (A, B, C, D) and simultaneously open said control valve (14) in continued fashion, when said control valve cannot independently provide increased oxygen in a timely manner responsive to increased load demand, whereby the power plant will not suffer from oxygen starvation during transient increases in load demand.

2. The fuel cell power plant of claims 1, wherein said microprocessor means (18) is further operable to close said fast acting valve means (A, B, C, D) when existing oxygen flow rate from said fast acting valve means and said control valve (14) reaches a previously inputtet value which is a precalculated amount capable of supporting the concurrently existing load demand.

3. The fuel cell power plant of any one of claims 1 to 2, wherein said fast acting valve means (A, B, C, D) comprises a plurality of solenoid valves, and wherein said microprocessor means (18) is operable to open less than all of said solenoid valves when oxygen supply shortfall from said control valve is a smaller first precalculated amount less than that required to support ongoing load demand, and is further operable to open all of said solenoid valves when oxygen supply shortfall from said control valve is a second larger amount less than that required to support ongoing load demand.

4. A method for supplying oxygen to a fuel cell system (2) of a fuel cell power plant during extended operating periods, said method comprising the steps of:

(a) blowing the required feed of oxygen through a conduit means (12) to an oxidation side (4) of said fuel cell system (2);

(b) continuously monitoring load demand imposed on said fuel cell system (2);

(c) continuously monitoring oxygen flow rate into said fuel cell system (2);

(d) periodically comparing measured loads and measured oxygen flow rates with a precalculated steady state flow schedule (W) and comparing measured oxygen flow rate deviations from said steady state flow schedule;

(e) gradually increasing the oxygen flow rates to the fuel cell system when said measured oxygen flow rate deviations are less than a first predetermined value by opening incrementally a motorized control valve (14) in said conduit means (12); and

(f) simultaneously substantially instantaneously providing augmented oxygen flow to increase the oxygen flow rates to the fuel cell system (2) when said oxygen flow rate deviations exceed said first predetermined value by opening fast acting valve means (A, B, C, D) arranged in branch conduit means (22, 24, 26, 28, 30, 32) bypassing said control valve (14).

5. The method of claim 4 further comprising the step of substantially instantaneously terminating the augmented oxygen flow when said oxygen flow rate deviations are below a second predetermined value which second predetermined value is less than said first predetermined value.

6. The method of claim 5 further comprising the step of continuing to gradually increase the oxygen flow rates after terminating the augmented oxygen flow, until such time as the measured oxygen flow rates conform to the precalculated steady state flow schedule (W), and thereafter providing a steady flow of oxygen.

Patentansprüche

1. Brennstoffzellen-Stromerzeugungsanlage mit einem System zur Zuführung von Sauerstoff an eine Oxidationsseite (4) der Zellen in der Anlage, wobei das System aufweist:

(a) eine Leitungseinrichtung (12) zur Zuführung von Sauerstoff zur Oxidationsseite (4) der Anlage;

(b) ein mit konstanter Geschwindigkeit ar-

beitendes Gebläse (10), das mit der Leitungseinrichtung (12) zur Schaffung der erforderlichen Zuführung von Sauerstoff verbunden ist;

(c) ein motorisiertes Steuerventil (14) in der Leitungseinrichtung (12) zwischen dem Gebläse (10) und der Oxidationsseite (4), wobei das Steuerventil einstellbar ist zur Änderung der zur Oxidationsseite strömenden Sauerstoffmenge;

(d) eine Abzweigleitungseinrichtung (22,24,26,28,30,32), die zu der Leitungseinrichtung (12) offen ist, um einen Sauerstoffströmungsweg von dem Gebläse (10) zur Oxidationsseite (4) zu schaffen, der das Steuerventil (14) umgeht;

(e) eine schnell agierende Ventileinrichtung (A,B,C,D) in der Abzweigleitungseinrichtung, wobei die schnell agierende Ventileinrichtung relativ augenblicklich von einem geschlossenen Zustand in einen geöffneten Zustand und umgekehrt bringbar ist, und wobei die schnell agierende Ventileinrichtung sich normalerweise in geschlossenem Zustand befindet;

(f) eine Durchflußmeßeinrichtung (20) in der Leitungseinrichtung (12) zur Messung der vom Steuerventil (14) und der schnell agierenden Ventileinrichtung (A,B,C,D) zur Oxidationsseite (4) strömenden Sauerstoffmengen;

(g) eine Stromüberwachungseinrichtung (34), die an eine von der Stromerzeugungsanlage abgehende Lastleitung angeschlossen ist, zur Überwachung von Laständerungen, die den Zellen (2) in der Stromerzeugungsanlage auferlegt werden; und

(h) eine Mikroprozessoreinrichtung (18) zur Steuerung des Betriebs des Systems, wobei die Mikroprozessoreinrichtung betriebsmäßig verbunden ist mit der Stromüberwachungseinrichtung (34), der Durchflußmeßeinrichtung (20), der schnell agierenden Ventileinrichtung (A,B,C,D) und dem Steuerventil (14), wobei die Mikroprozessoreinrichtung betreibbar ist zur:

(i) Aufnahme von Last- und Sauerstoffsströmungsdaten von der Überwachungseinrichtung (34) und der Sensoreinrichtung (20);

(ii) kontinuierlichen Bestimmung, ob das Steuerventil (14) fähig ist, genügend Sauerstoff zu liefern, um die bestehenden Lastanforderungen zu befriedigen;

(iii) zunehmenden Öffnung des Steuerventils (14), wenn das Steuerventil (14) unabhängig rechtzeitig mehr Sauerstoff in Reaktion auf angestiegene Lastanforderung bereitstellen kann; und

(iv) Öffnung der schnell agierenden Ventileinrichtung (A,B,C,D) und gleichzeitigen, fortschreitenden Öffnung des Steuerventils (14), wenn das Steuerventil (14) nicht unabhängig rechtzeitig mehr Sauerstoff in Reaktion auf angestiegene Lastanforderung bereitstellen kann, wodurch die Stromerzeugungsanlage während Übergangsanstiegen der Lastanforderung nicht an Sauerstoffmangel leidet.

2. Brennstoffzellen-Stromerzeugungsanlage nach Anspruch 1, bei der die Mikroprozessoreinrichtung (18) darüber hinaus betreibbar ist zum Schließen der schnell agierenden Ventileinrichtung (A,B,C,D), wenn der bestehende Sauerstoffdurchsatz von der schnell agierenden Ventileinrichtung und dem Steuerventil (14) einen vorher eingegebenen Wert erreicht, der einer vorausberechneten Menge entspricht, die in der Lage ist, die gleichzeitig bestehende Lastanforderung zu stützen.

3. Brennstoffzellen-Stromerzeugungsanlage nach Anspruch 1 oder 2, bei der die schnell agierende Ventileinrichtung (A,B,C,D) mehrere Magnetventile aufweist, und bei der die Mikroprozessoreinrichtung (18) betreibbar ist zum Öffnen von weniger als sämtlichen Magnetventilen, wenn der Sauerstoffversorgungsmangel vom Steuerventil um eine kleinere, erste, vorausberechnete Menge kleiner ist als die Menge, die erforderlich ist, um die fortbestehende Lastanforderung zu stützen, und darüber hinaus betreibbar ist, zum Öffnen sämtlicher Magnetventile, wenn der Sauerstoffversorgungsmangel von dem Steuerventil um eine zweite, größere Menge kleiner ist als die Menge, die erforderlich ist, um die fortbestehende Lastanforderung zu stützen.

4. Verfahren zur Sauerstoffversorgung eines Brennstoffzellensystems (2) einer Brennstoffzellen-Stromerzeugungsanlage während ausgedehnter Betriebsperioden, wobei das Verfahren die folgenden Schritte aufweist:

(a) Einblasung der erforderlichen Zuführung von Sauerstoff durch eine Leitungseinrichtung (12) zu einer Oxidationsseite (4) des Brennstoffzellensystems (2);

(b) fortlaufende Überwachung der Lastanforderung, die dem Brennstoffzellensystem (2) auferlegt ist;

(c) fortlaufende Überwachung des Sauerstoffdurchsatzes in das Brennstoffzellensystem (2);

(d) periodisches Vergleichen gemessener

Lasten und gemessener Sauerstoffdurchsätze mit einer vorausberechneten Strömungsvorgabe (W) für den stabilen Zustand und Vergleichen der gemessenen Sauerstoffdurchsatzabweichungen von der Strömungsvorgabe für den stabilen Zustand;

(e) allmähliches Erhöhen der Sauerstoffdurchsätze zum Brennstoffzellensystem, wenn die gemessenen Sauerstoffdurchsatzabweichungen kleiner als ein erster vorbestimmter Wert sind, durch zunehmendes Öffnen eines motorisierten Steuerventils (14) in der Leitungseinrichtung (12); und

(f) gleichzeitige, im wesentlichen augenblickliche Bereitstellung einer erhöhten Sauerstoffströmung, um die Sauerstoffdurchsätze zum Brennstoffzellensystem (2) zu erhöhen, wenn die Sauerstoffdurchsatzabweichungen den ersten, vorbestimmten Wert überschreiten, durch Öffnen einer schnell agierenden Ventileinrichtung (A,B,C,D), die in einer das Steuerventil (14) umgehenden Abzweigleitungseinrichtung (22,24,26,28,30,32) angeordnet ist.

5. Verfahren nach Anspruch 4, darüber hinaus aufweisend den Verfahrensschritt, daß die erhöhte Sauerstoffströmung im wesentlichen augenblicklich beendet wird, wenn die Sauerstoffdurchsatzabweichungen unterhalb eines zweiten, vorbestimmten Wertes liegen, wobei der zweite, vorbestimmte Wert kleiner ist als der erste, vorbestimmte Wert.

6. Verfahren nach Anspruch 5, weiterhin aufweisend den Verfahrensschritt, daß das allmähliche Erhöhen der Sauerstoffdurchsätze nach Beendigung der erhöhten Sauerstoffströmung bis zu der Zeit fortgesetzt wird, wenn die gemessenen Sauerstoffdurchsätze übereinstimmen mit der vorausberechneten Strömungsvorgabe (W) für den stabilen Zustand, und daß danach eine gleichbleibende Sauerstoffströmung vorgesehen wird.

Revendications

1. Dispositif de fourniture d'énergie, à pile à combustible, comportant un système pour fournir de l'oxygène à un côté oxydation (4) des piles situées dans le dispositif, ledit système comprenant :

(a) un conduit (12) pour amener l'oxygène audit côté oxydation (4) dudit dispositif;

(b) une soufflante (10) à vitesse constante, reliée audit conduit (12), pour fournir le débit requis d'oxygène;

(c) une valve de commande motorisée (14), située dans ledit conduit (12), entre ladite soufflante (10) et ledit côté oxydation (4), ladite valve de commande étant réglable de façon à faire varier la quantité d'oxygène s'écoulant vers ledit côté oxydation;

(d) des conduits d'embranchement (22,24,26,28,30,32) débouchant dans ledit conduit (12), pour produire un chemin d'écoulement d'oxygène allant de ladite soufflante (10) audit côté oxydation (4), qui constitue une dérivation de la valve de commande (24);

(e) une soupape à action rapide (A,B,C,D), montée dans ledit conduit d'embranchement, ladite soupape à action rapide étant transformable, de façon relativement instantanée, d'un état fermé à un état ouvert et inversement, et ladite soupape à action rapide étant normalement dans ledit état fermé;

(f) un débitmètre (20), monté dans ledit conduit (12), pour mesurer les quantités d'oxygène s'écoulant depuis la valve de commande (14) et les soupapes à action rapide (A,B,C,D) vers le côté oxydation (4);

(g) un moyen de surveillance de courant (34), relié à une ligne de charge, depuis le dispositif de fourniture d'énergie, pour surveiller les variations de charge selon les piles (2) situées dans le dispositif de fourniture d'énergie; et

(h) un microprocesseur (18), pour commander le fonctionnement dudit système, ledit microprocesseur étant relié fonctionnellement audit moyen de surveillance de courant (34), audit débitmètre (20), auxdites soupapes à action rapide (A,B,C,D) et à ladite valve de commande (14), ledit microprocesseur étant susceptible de fonctionner pour :

(i) recevoir des données de charge et d'écoulement d'oxygène provenant desdits moyens de surveillance (34) et de capteur de débit (20), respectivement;

(ii) déterminer de façon continue si la valve de commande (14) est en mesure de fournir suffisamment d'oxygène pour satisfaire les demande de charge exigées;

(iii) ouvrir ladite valve de commande (14) de façon incrémentielle, lorsque ladite valve de commande peut fournir indépendamment plus d'oxygène, d'une manière cadencée en fonction du temps, pour réagir à la demande accrue de charge; et

(iv) ouvrir ladite soupape à action rapide (A,B,C,D) et, simultanément, ouvrir ladite

valve de commande (14), de façon continue, lorsque ladite valve de commande ne peut fournir, indépendamment, une quantité accrue d'oxygène, de manière cadencée en fonction du temps, pour réagir à la demande accrue de charge, de manière à ce que le dispositif de fourniture d'énergie ne souffre pas d'un manque d'oxygène pendant les augmentations transitoires de la demande de charge.

2. Dispositif selon la revendication 1, dans lequel ledit microprocesseur (18) est en outre susceptible de fonctionner pour fermer ladite soupape à action rapide (A,B,C,D) lorsque le débit d'oxygène existant provenant de ladite soupape à action rapide et de ladite valve de commande (14) atteint une valeur introduite au préalable, qui est une quantité précalculée, pouvant supporter la demande de charge existant simultanément.

3. Dispositif selon l'une quelconque des revendications 1 et 2, dans lequel ladite soupape à action rapide (A,B,C,D) comprend une pluralité d'électrovannes et dans lequel ledit microprocesseur (18) peut fonctionner pour ouvrir, moins que la totalité desdites électrovannes, lorsque le manque d'alimentation en oxygène depuis ladite valve de commande a une première valeur inférieure précalculée, inférieure à celle qui est requise pour supporter la demande de charge en cours, et peut fonctionner en outre pour ouvrir la totalité desdites électrovannes, lorsque le manque d'alimentation en oxygène depuis ladite valve de commande a une deuxième valeur supérieure, inférieure à celle requise pour supporter la demande de charge en cours.

4. Procédé pour fournir de l'oxygène à un système à pile à combustible (2) d'un dispositif de fourniture d'énergie à pile à combustible, durant des périodes de fonctionnement étendues, ledit procédé comprenant les étapes de :

(a) soufflage du débit requis d'oxygène, par l'intermédiaire d'un conduit (12), à un côté oxydation (4) dudit système à pile à combustible (2);

(b) surveillance continue de la demande de charge imposée audit système à piles à combustible (2);

(c) surveillance continue du débit d'oxygène introduit dans ledit système à piles à combustible (2);

(d) comparaison périodique des charges mesurées et des débits d'oxygène mesurés avec un modèle à écoulement en état permanent (W) précalculé et comparaison des écarts sur le débit d'oxygène mesuré à partir dudit modèle à écoulement en état permanent;

(e) augmentation graduelle des débits d'oxygène introduits dans le système à piles à combustible, lorsque les écarts de débit d'oxygène mesuré sont inférieurs à une première valeur prédéterminée, par une ouverture incrémentée d'une valve de commande motorisée (14) placée dans ledit conduit (12); et

(f) fourniture simultanée et pratiquement instantanée d'un courant d'oxygène augmenté pour augmenter les débits d'oxygène allant au système de pile à combustible (2)), lorsque lesdits écarts de débit d'oxygène dépassent ladite première valeur prédéterminée, par ouverture de la soupape à action rapide (A,B,C,D) disposé dans le conduit d'embranchement (22,24,26,28,30,32) en opérant une dérivation de ladite valve de commande (14).

5. Procédé selon la revendication 5, comprenant en outre l'étape d'achèvement pratiquement instantanée de la fourniture d'un courant d'oxygène augmenté, lorsque lesdits écarts de débit d'oxygène descendent au-dessous d'une deuxième valeur prédéterminée qui est elle-même inférieure à ladite première valeur prédéterminée.

6. Procédé selon la revendication 6, comprenant en outre l'étape de continuation de l'augmentation graduelle des débits d'oxygène après l'achèvement de la fourniture d'un courant d'oxygène augmenté, jusqu'à atteindre le moment auquel les débits d'oxygène mesurés se conforment au modèle d'écoulement en état permanent (W) précalculé, et fournir ensuite un écoulement d'oxygène constant.

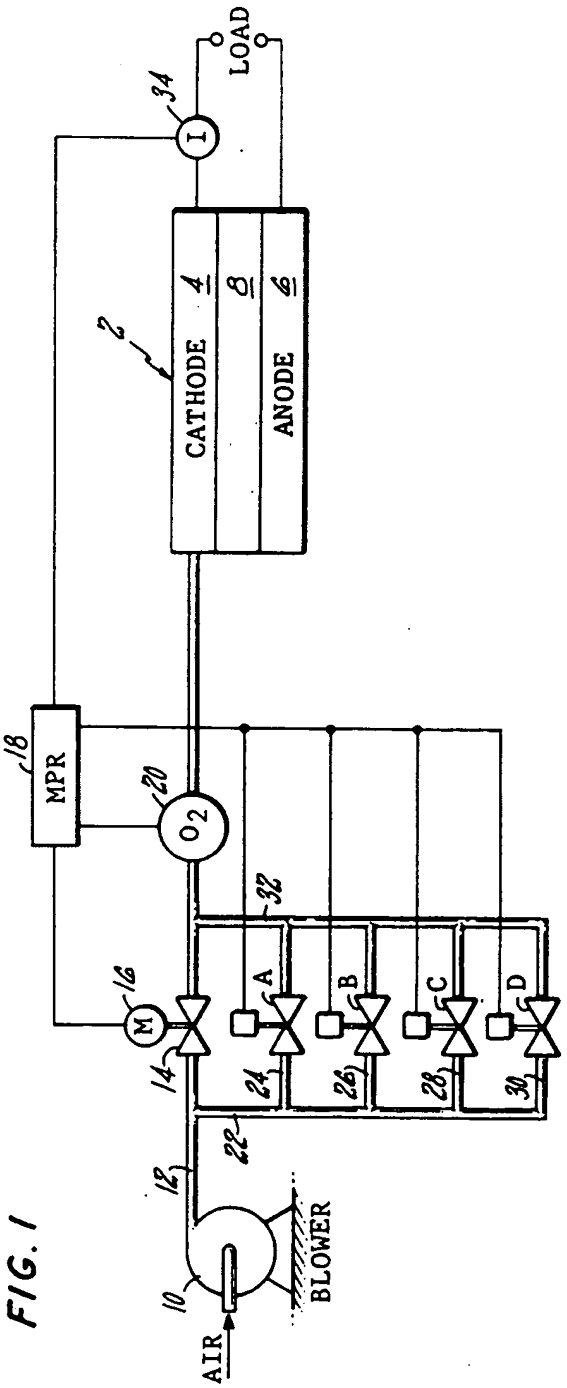

FIG. 1

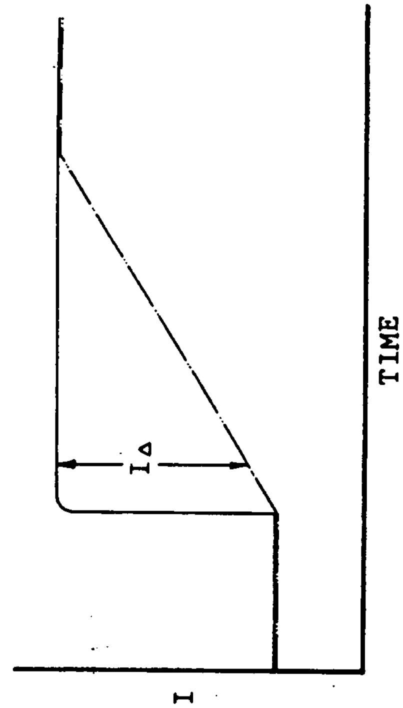

FIG. 2

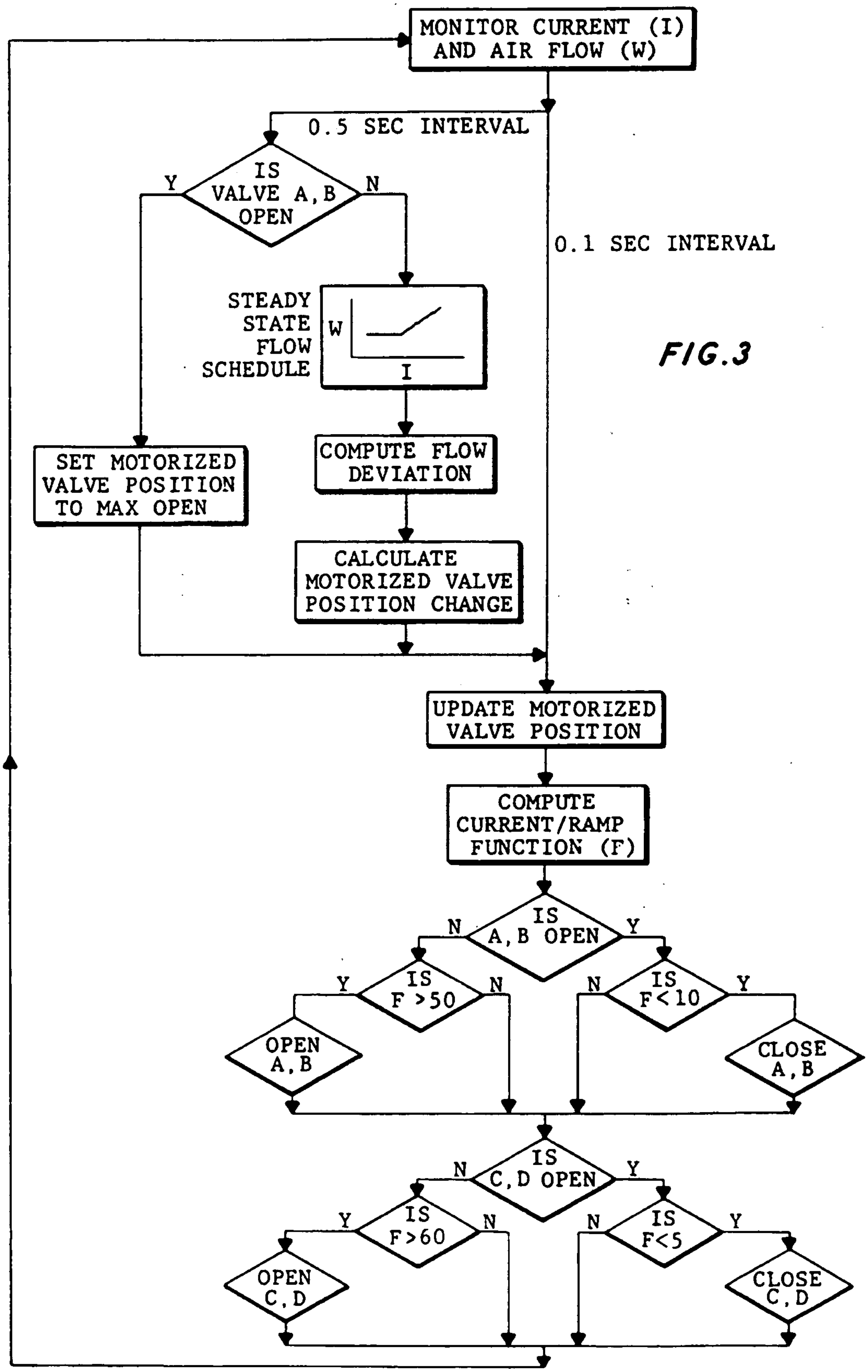
MONITOR CURRENT (I) AND AIR FLOW (W)
0.5 SEC INTERVAL
0.1 SEC INTERVAL
IS VALVE A,B OPEN
Y
N
STEADY STATE FLOW SCHEDULE
W
I
SET MOTORIZED VALVE POSITION TO MAX OPEN
COMPUTE FLOW DEVIATION
CALCULATE MOTORIZED VALVE POSITION CHANGE
UPDATE MOTORIZED VALVE POSITION
COMPUTE CURRENT/RAMP FUNCTION (F)
IS A,B OPEN
IS F >50
IS F<10
OPEN A,B
CLOSE A,B
IS C,D OPEN
IS F>60
IS F<5
OPEN C,D
CLOSE C,D

FIG.3